

EFFECT OF COMPOST, BIO AND NPK FERTILIZATION ON ESSENTIAL OIL PRODUCTION OF YARROW FLOWERING TOPS, *ACHILLEA MILLEFOLIUM*, L.

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Scientific J. Flowers & Ornamental Plants, 2(2):167-174 (2015).

Received:

22/7/2015

Revised by:

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ABSTRACT: The effects of compost (5, 7.5 and 10 ton/fed), NPK (50, 75 and 100%) and/or Effective micro-organisms/Minia Azotein fertilization on plant height, number and dry weight of flowering tops/plant and essential oil productivity (% and yield/plant) were investigated during 2012/2013 and 2013/2014 at the experimental farm, Fac. of Agric., Minia Univ.

All treatments of compost significantly increased, plant height, number and dry weight of flowering tops/plant, as well as, essential oil percent and yield/plant. The high level of compost was more effective in this concern.

The used of mineral NPK (100%) followed by 75% NPK + E.M. + M.A. treatments were the best results in increasing all previous characters.

Generally supplying yarrow plants with compost at the rate of 10 ton/fed and fertilizing plants with NPK (100%) or reduce dose at (75% NPK) plus E.M. + M.A. gave overall the highest values of previous traits.

Key words: *Achillea millefolium*, L., compost, biofertilization, E.M., NPK, flowering tops, essential oil.

INTRODUCTION

Achillea millefolium, L. (Fam. Asteraceae). Common name: yarrow. For medicinal purpose it has been used as administrated both internally and externally. It is valuable for treating wounds, stopping the flow of blood, treating colds, fevers, kidney diseases and menstrual pain (Duke, 1985, Bown, 1995, Chevallier, 1996 and Noerman, 1998).

Organic fertilizers are very important due to their beneficial effects on the soil, growth and increase the productivity, as well as, improving the quality of plant production (Aziz and Iman, 2004; Harb and Mahmoud, 2009 and Ferraz *et al.*, 2014 on *Achillea millefolium*).

Chemical nutrients especially N, P and K are very important for plant growth and productivity (Giorgi *et al.*, 2009 on *Achillea collina*; El-Mekawy, 2013 on *Achillea santolina* and Abd El-Latif, 2014 on lavender).

Biofertilizers increase crop growth and productivity through different mechanisms, i.e. biological nitrogen fixation as Effective micro-organisms and Minia Azotein, growth promoting or hormonal substances, increasing availability of soil nutrients (Hedge *et al.*, 1999; El-Mekawy, 2013 on *Achillea santolina* and Panah and Vash, 2014 on *Calendula officinalis*).

Therefore, the purposes of this research were to investigate the effect of compost,

mineral NPK and/or biofertilization treatments on growth and essential oil production of yarrow plants.

MATERIALS AND METHODS

This research was carried out at the experimental farm of Fac. of Agric., Minia Univ., during two consecutive seasons (2012/2013 and 2013/2014). Mechanical and chemical analysis of the soil were performed according to (Jackson, 1973) as shown in (Table, a).

Also, chemical characteristics of compost (Table, b), which obtained from the Egyptian Co. for Solid Waste Utilization, New Minia City.

Biofertilizers namely, Effective micro-organisms (E.M., containing photosynthetic bacteria + lactic acid + yeasts) and Minia Azotein (M.A., containing N-fixing bacteria) were obtained from the Laboratory of

Biofertilizers, Dept. of Genetics, Fac. Agric., Minia Univ.).

The experiment was arranged in a randomized complete blocks design in a split-plot with three replicates. The main plots (A) included four treatments of compost (control, 5, 7.5 and 10 ton/fed). While seven treatments of mineral NPK and/or biofertilization occupied the sub-plots (B) (100% NPK, 75% NPK + E.M., 50% NPK + E.M., 75% NPK + M.A., 50% NPK + M.A., 75% NPK + E.M. + M.A. and 50% NPK + E.M. + M.A.).

The experimental unit (pot) was 3.0×2.4 m and containing 5 rows, 60 cm apart. The seedlings were transplanted as individual plants in hills, 40 cm apart, therefore, each plot contained 30 plants.

Compost was added during preparing the soil to cultivation in both seasons.

Table a. Physical and chemical analysis of the experimental soil.

Soil Character	Value	Soil Character	Value	
Sand %	28.30	Available P %	15.12	
Silt %	30.70	Exch. K ⁺ (mg/100 g soil)	2.11	
Clay %	41.00	Exch. Ca ⁺⁺ (mg/100 g soil)	31.74	
Soil type	Clayey loam	Exch. Na ⁺ (mg/100 g soil)	2.41	
Organic matter %	1.62	Fe	8.54	
CaCO ₃ %	2.09	Cu	2.06	
E.C. (mmhos/cm)	1.04	DTPA	Zn	2.75
pH (1:2.5)	7.83	Ext. ppm	Mn	8.26
Total N %	0.08			

Table b. Physical and chemical properties of the used compost.

Properties	Values	Properties	Values
Dry weight of 1 m ³	450 kg	C/N ratio	18.5-14.1
Fresh weight of 1 m ³	650-700 kg	NaCl %	1.1-1.75
Moisture (%)	25-30	Total P %	0.5-0.75
pH (1:10)	7.5-8	Total K %	0.8-1.0
E.C. (m mhose/cm)	2-4	Fe ppm	150-200
Total N %	1-1.4	Mn ppm	25.56
Org. matter %	32-34	Cu ppm	75-150
Org. carbon %	18.5-19.7	Zn ppm	150-225

The recommended mineral NPK fertilization (full dose) 100% NPK was 300 kg/fed ammonium nitrate (33.5% N), 100 kg/fed calcium superphosphate (15.5% P₂O₅) and 50 kg/fed potassium sulphate (48% K₂O) according to El-Sayed (1986). While, 75% NPK were 225+75+37.5 kg/fed and 50% NPK were 150+50+25 kg/fed, respectively. All amounts of P fertilizer were added during the preparing the soil, while the amounts of mineral NK fertilizers were divided into three equal batches and added at one month interval, starting December 25th in both seasons.

Fresh and active two biofertilizers, Effective micro-organisms (E.M.) and Minia Azotein (M.A.) applied either separately or in a mixture at three times at one month interval starting December 18th for both seasons. Biofertilizers were added to the soil around each seedling (50 ml/seedling, 1 ml=10⁷ cells) and then seedlings were irrigated immediately. All other agricultural practices were carried out as usual in the region.

At the end of experiment, the following data were recorded: plant height (cm), number of flowering tops per plant (flowering tops were collected 4 times every one month during the flowering season), dry weight of flowering tops/plant, essential oil percentage, oil yield (ml/plant).

Air-dried flower tops in each treatment carefully hand crushed to measure the percentage of essential oil according to (British Pharmacopoeia, 1963) by distilling 25 g of flowers for 4 hours in order to extract the essential oil.

The obtained data were tabulated and statistically analyzed according to MSTAT-C (1986) and L.S.D. test at 5 % was followed to compare between the means.

RESULTS AND DISCUSSION

1- Plant height (cm):

Data obtained in (Table, 1) indicated that plant height was significantly increased as the compost treatments increased. So

maximum plant height (88.1 and 89.8 cm for the first and second season, respectively) was achieved on 10 ton/fed compost. Several studies showed that compost could increase the growth of some medicinal plants such as yarrow (Aziz and Iman, 2004 and Harb and Mahmoud, 2009) and sage (Abdou *et al.*, 2012).

Also, data in Table (1) indicated that, supplying yarrow plants with E.M. and/or M.A. combined with 75 or 50% NPK of the recommended dose resulted in a significant decrease on plant height in comparison with control (100% NPK) in both seasons. The least reduction of the plant height was recorded with the treatment of 75% NPK + E.M. + M.A. The response of plant height to chemical NPK fertilization was reported by El-Mekawy (2013) on *Achillea santolina* and Jadhav *et al.* (2014) on *Tagetes erecta*. The interaction treatments was significant. The tallest plants produced by using 10 ton/fed compost in combination with 100% NPK.

2- Flowering aspects:

Data presented in Table (1) indicated that number and dry weight of flowering tops/plant of yarrow were gradually increased, in both seasons, parallel to the increase in compost level. The high level of compost (10 ton/fed) gave significantly higher values in both seasons than other treatments. Similar results were obtained by Harb and Mahmoud (2009) on yarrow and Ali (2013) on *Calendula officinalis*.

Concerning the treatments of mineral NPK and/or biofertilization data in Table (1) showed that fertilizing yarrow with NPK (100%) followed by 75% NPK plus E.M. + M.A. produced the highest number and dry weight of flowering tops/plant in both seasons comparing with other five used treatments.

The role of NPK fertilizers in augmenting yield and weight of flowers was found by Harb and Mahmoud (2009) and El-Mekawy (2013) on *Achillea* spp. and Khalif *et al.* (2014) and Maleki *et al.* (2014) on *Calendula officinalis*. Meanwhile, the

Table 1. Effect of compost, bio and NPK fertilization on plant height (cm), number of flowering tops/plant and dry weight of flowering tops/plant of yarrow (*Achillea millefolium*, L.) plants during first and second seasons (2012/2013 and 2013/2014).

Bio and NPK fertilization treatments (B)	Compost levels (ton/fed) (A)										
	1 st season					2 nd season					
	0.0	5.0	7.5	10.0	Mean (B)	0.0	5.0	7.5	10.0	Mean (B)	
Plant height (cm)											
100% NPK	86.9	89.1	97.5	99.0	93.2	88.7	90.9	99.0	101.0	95.0	
75% NPK + E.M.	70.2	80.4	94.1	94.8	84.9	71.6	82.0	96.0	96.7	86.6	
50% NPK + E.M.	63.0	75.2	73.8	81.9	73.5	64.3	76.8	75.2	83.5	75.0	
75% NPK + M.A.	68.7	79.2	86.4	92.3	81.6	70.0	80.8	88.1	94.2	83.3	
50% NPK + M.A.	58.1	60.6	55.2	65.3	59.9	59.3	61.7	56.3	66.7	61.0	
75% NPK+E.M.+M.A.	71.1	87.3	95.4	95.9	87.5	72.5	89.0	97.3	97.8	89.2	
50% NPK+E.M.+M.A.	65.1	78.6	78.3	87.3	77.3	66.3	80.1	79.8	89.0	78.8	
Mean (A)	69.0	78.7	82.96	88.1		70.4	80.2	84.6	89.8		
L.S.D. at 5%	A= 2.97		B= 2.1		AB= 4.2		A= 3.28		B= 0.94		AB= 1.88
Number of flowering tops/plant											
100% NPK	45.32	48.77	50.29	54.40	49.70	47.68	49.91	52.54	54.86	51.26	
75% NPK + E.M.	41.19	43.23	45.47	47.46	44.34	41.40	44.01	46.32	47.85	44.90	
50% NPK + E.M.	34.67	35.91	37.66	39.68	37.00	33.10	35.60	37.52	40.08	36.58	
75% NPK + M.A.	39.46	40.40	42.82	45.00	41.93	38.22	39.92	42.23	44.42	41.21	
50% NPK + M.A.	29.72	31.32	33.86	35.79	32.67	28.71	32.24	34.11	37.28	33.09	
75% NPK+E.M.+M.A.	43.83	47.62	49.43	51.84	48.19	46.68	48.31	50.95	53.32	49.82	
50% NPK+E.M.+M.A.	37.78	38.88	39.91	42.06	39.66	36.32	37.56	39.81	41.16	38.71	
Mean (A)	38.85	40.87	42.78	45.17		38.87	41.08	43.36	45.57		
L.S.D. at 5 %	A= 1.39		B= 1.60		AB= 3.20		A= 1.21		B= 1.51		AB= 3.02
Dry weight of flowering tops /plant (g/plant)											
100% NPK	54.75	58.92	60.76	65.70	60.03	57.60	60.29	63.48	66.27	61.92	
75% NPK + E.M.	49.86	52.33	55.05	57.46	53.68	50.12	53.28	56.08	57.93	54.35	
50% NPK + E.M.	42.25	43.76	45.90	48.36	45.07	40.33	43.39	45.73	48.85	44.58	
75% NPK + M.A.	47.88	49.02	51.96	54.61	50.88	46.38	48.46	51.25	53.90	50.00	
50% NPK + M.A.	36.30	38.25	41.35	43.71	39.90	35.06	39.37	41.68	45.54	40.42	
75% NPK+E.M.+M.A.	53.07	57.66	59.85	62.77	58.34	56.51	57.30	62.88	66.65	60.84	
50% NPK+E.M.+M.A.	45.95	47.03	48.77	51.14	48.22	49.29	45.07	47.75	49.37	47.87	
Mean (A)	47.15	49.57	51.94	54.82		47.90	49.59	52.70	55.50		
L.S.D. at 5%	A= 1.98		B=1.70		AB= 3.40		A= 1.68		B= 1.28		AB= 2.56

E.M.: Effective micro-organisms

M.A.: Minia Azotein (N-fixing bacteria)

Table 2. Effect of compost, bio and NPK fertilization on oil percentage and oil yield/plant of yarrow (*Achillea millefolium*, L.) plants during first and second seasons (2012/2013 and 2013/2014).

Bio and NPK fertilization treatments (B)	Compost levels (ton/fed) (A)										
	1 st season					2 nd season					
	0.0	5.0	7.5	10.0	Mean (B)	0.0	5.0	7.5	10.0	Mean (B)	
Essential oil percentage											
100% NPK	0.672	0.736	0.774	0.800	0.746	0.673	0.742	0.793	0.796	0.751	
75% NPK + E.M.	0.543	0.565	0.593	0.609	0.578	0.546	0.572	0.581	0.606	0.576	
50% NPK + E.M.	0.450	0.479	0.511	0.542	0.496	0.445	0.475	0.504	0.533	0.489	
75% NPK + M.A.	0.476	0.549	0.562	0.600	0.547	0.477	0.540	0.568	0.585	0.542	
50% NPK + M.A.	0.384	0.428	0.446	0.469	0.432	0.387	0.425	0.463	0.482	0.439	
75% NPK+E.M.+M.A.	0.697	0.719	0.748	0.756	0.730	0.713	0.731	0.746	0.755	0.736	
50% NPK+E.M.+M.A.	0.463	0.504	0.542	0.568	0.519	0.463	0.505	0.536	0.559	0.516	
Mean (A)	0.514	0.555	0.583	0.606		0.514	0.555	0.583	0.601		
L.S.D. at 5%	A= 0.022		B= 0.022		AB= 0.044		A= 0.016		B= 0.024		AB= 0.048
Essential oil yield/plant (ml/plant)											
100% NPK	0.37	0.43	0.47	0.53	0.45	0.39	0.45	0.50	0.53	0.47	
75% NPK + E.M.	0.27	0.30	0.33	0.35	0.31	0.27	0.30	0.33	0.35	0.31	
50% NPK + E.M.	0.19	0.21	0.23	0.26	0.22	0.18	0.21	0.23	0.26	0.22	
75% NPK + M.A.	0.23	0.27	0.29	0.33	0.28	0.22	0.26	0.29	0.32	0.27	
50% NPK + M.A.	0.14	0.16	0.18	0.20	0.17	0.14	0.17	0.19	0.22	0.18	
75% NPK+E.M.+M.A.	0.37	0.41	0.45	0.47	0.43	0.40	0.42	0.47	0.50	0.45	
50% NPK+E.M.+M.A.	0.21	0.24	0.26	0.29	0.25	0.23	0.23	0.26	0.28	0.25	
Mean (A)	0.24	0.28	0.30	0.33		0.25	0.28	0.31	0.33		
L.S.D. at 5%	A= 0.02		B= 0.04		AB= 0.08		A= 0.02		B= 0.03		AB= 0.06

E.M.: Effective micro-organisms

M.A.: Minia Azotein (N-fixing bacteria)

efficiency of biofertilizers was revealed by Abd El-Raaof (2009) on borage and Shivaprakash *et al.* (2011) on *Tagetes erecta*.

The interaction treatments was significant in both seasons and the highest values were obtained with the interaction treatments of compost (10 ton/fed) × 100% NPK followed by compost (10 ton/fed) × 75% NPK + E.M. + M.A.

3- Essential oil production:

Data presented in Table (2) indicated that all of the three tested treatments of compost (5, 7.5 and 10 ton/fed) gave significantly in the two seasons higher

percentage and yield of essential oil/plant than that of the control. The high level of compost recorded the highest values.

Applying organic manure not only relieved material inhibition an autotoxic substance in the root exudates by cinnamic acid but also promoted growth, increased the content and composition of plant secondary metabolites (essential oils or alkaloids), (Zheljzakov, 2005).

Supplying plants with adequate quantities of NPK led to an increase in growth consequently, increasing the overall flower production which reflect on essential

oil yield similar, Giorgi *et al.* (2009) on *Achillea collina*, El-Mekawy (2013) on *Achillea santolina* and Abd El-Latif (2014) on lavender plants.

Moreover, microbiological fertilizer has a positive effect in growing the plants to their development and metabolism and reported by Abd El-Raaof (2009) on borage and Saburi *et al.* (2014) on basil.

Also, data in Table (2) indicated that significant differences were obtained among the seven tested treatments in both seasons. The highest essential oil percentage and yield/plant was given by 100% NPK treatment or 75% NPK + E.M. + M.A. with no significant differences being obtained between them.

The interaction between compost and mineral NPK and/or biofertilization treatments was significant for essential oil % and yield per plant in both seasons. The best overall results, among different interaction treatments were obtained due to compost at high level (10 ton/fed) in combination with 100% NPK or 75% NPK plus E.M. + M.A.

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تأثير معاملات الكمبوست والتسميد الحيوي والمعدني على إنتاج الزيت الطيار لأزهار الأشيليا

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أجري هذا البحث في مزرعة التجارب بكلية الزراعة جامعة المنيا وذلك لدراسة تأثير الكمبوست (5، 7، 5 و 10 طن/فدان) والتسميد المعدني (50، 75 و 100%) و/أو الميكروبات الدقيقة النشيطة والمنيا أزوتين على ارتفاع وعدد الوزن الجاف للقمم الزهرية وإنتاج الزيت الطيار (النسبة المئوية ومحصول الزيت للنبات) تم بحثها في عامي 2012/2013 و 2013/2014 بمزرعة التجارب بكلية الزراعة – جامعة المنيا. وكان من أهم النتائج المتحصل عليها:
1- كل مستويات الكمبوست أدت إلى زيادة معنوية في ارتفاع النبات وعدد والوزن الجاف للقمم الزهرية للنبات وكذلك النسبة المئوية للزيت الطيار ومحصول الزيت الطيار للنبات وكان المستوى العالي من الكمبوست أكثر فاعلية في هذا الشأن.

٢- استخدام معاملات التسميد المعدني النتروجيني الفوسفوري البوتاسي (١٠٠%) متبوعاً ب ٧٥% من التسميد المعدني + الميكروبات الدقيقة النشطة + المنيا أزوتين كانتا أحسن النتائج في زيادة الصفات السابقة. عموماً إمداد نبات الأشيليا بالكمبوست ١٠ طن/فدان وتسميد النباتات بالتسميد المعدني ن فو بو (١٠٠%) أو تقليل الجرعة من السماد الكيماوي وذلك بالتسميد بالجرعة المختزلة ٧٥% ن فو بو بالإضافة إلى M.A. + E.M. أعطت أعلى قيم لجميع الصفات المدروسة وذلك للحصول على نتائج أفضل.